



(43) International Publication Date
28 November 2002 (28.11.2002)

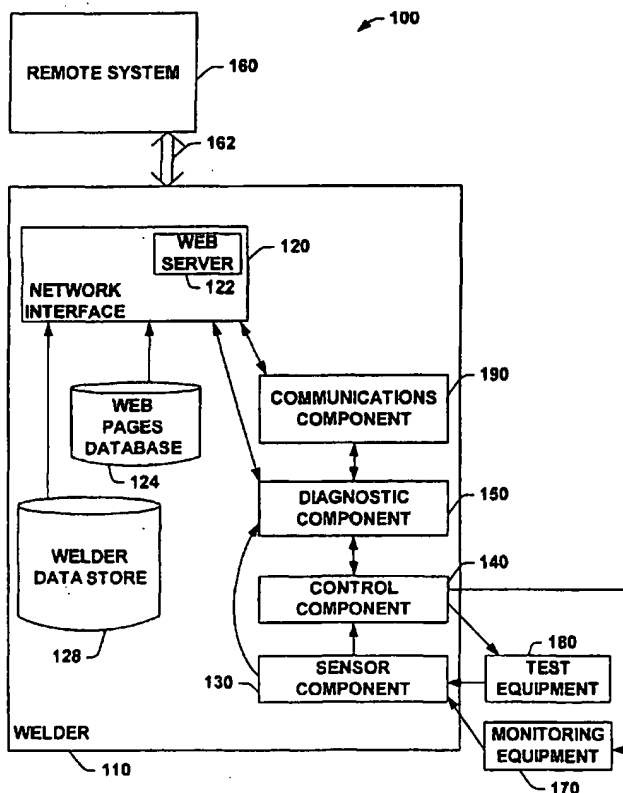
PCT

(10) International Publication Number
WO 02/095323 A1

- | | |
|--|--|
| <p>(51) International Patent Classification⁷: G01B 3/44, 3/52</p> <p>(21) International Application Number: PCT/US02/14388</p> <p>(22) International Filing Date: 8 May 2002 (08.05.2002)</p> <p>(25) Filing Language: English</p> <p>(26) Publication Language: English</p> <p>(30) Priority Data:
 09/864,741 24 May 2001 (24.05.2001) US</p> <p>(71) Applicant: LINCOLN GLOBAL, INC. [US/US]; 1200
 Monterey Pass Road, Monterey Park, CA 44024 (US).</p> <p>(72) Inventors: DODGE, Robert; 7985 Sweetgum Trail,
 Concord, OH 44060 (US). HILLEN, Edward, Dennis;
 5670 Canyon View Drive, Painesville, OH 44077 (US).</p> | <p>BLANKENSHIP, George, Daryl; 12221 Bradford Drive,
 Chardon, OH 44024 (US).</p> <p>(74) Agents: AMIN, Himanshu, S. et al.; Amin & Turocy,
 L.L.P., 1900 E. 9th Street, 24th Floor, National City Center,
 Cleveland, OH 44114 (US).</p> <p>(81) Designated States (national): AE, AG, AL, AM, AT, AU,
 AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,
 CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,
 GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,
 LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,
 MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG,
 SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VN,
 YU, ZA, ZM, ZW.</p> <p>(84) Designated States (regional): ARIPO patent (GH, GM,
 KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),
 Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
 European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR,</p> |
|--|--|

[Continued on next page]

- (54) Title:** SYSTEM AND METHOD FOR FACILITATING WELDING SYSTEM DIAGNOSTICS



(57) Abstract: A system and method for facilitating welding system diagnostics is provided. The invention includes a welder (110, 210, 510, 610), a local system (580), a remote system (160, 640), and/or an alarm component (290, 670). The invention provides for receiving sensor input(s), performing test sequence(s) based, at least in part, upon the sensor input(s) and/or performing internal diagnostics. A health status of the welder (110, 210, 510, 610) is determined and communicated to the local system (580), the remote system (160, 640) and/or the alarm component (290, 670). An expert component (592, 642) is employed to facilitate welding diagnostics based, at least in part, upon the health status of the welder (110, 210, 510, 610), welder data (128, 520, 624), an expert data store (594), a local service support data store (586), a remote expert data store (598, 650) and/or a remote service support data store (596, 660). Furthermore, a corrective action can be initiated by the welder (110, 210, 510, 610), local system and/or remote system (160, 640), at least temporarily, based, at least in part, upon the health status of the welder (110, 210, 510, 610).



GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent
(BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR,
NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

— *with international search report*

Title: SYSTEM AND METHOD FOR FACILITATING WELDING
SYSTEM DIAGNOSTICS

TECHNICAL FIELD

5 The present invention relates generally to computer and welding systems. More particularly, the present invention relates to a system and method for facilitating welding system diagnostics.

BACKGROUND

10 Welding systems reside at the core of the modern industrial age. From massive automobile assembly operations to automated manufacturing environments, these systems facilitate joining in ever more complicated manufacturing operations. One such example of a welding system includes an electric arc welding system. This may involve movement of a consumable
15 electrode, for example, toward a work piece while current is passed through the electrode and across an arc developed between the electrode and the work piece. The electrode may be a non-consumable or consumable type, wherein portions of the electrode may be melted and deposited on the work piece. Often, hundreds or perhaps thousands of welders are employed to drive
20 multiple aspects of an assembly process, wherein sophisticated controllers enable individual welders to operate within relevant portions of the process. For example, some of these aspects relate to control of power and waveforms supplied to the electrode, movements or travel of a welding tip during welding, electrode travel to other welding points, gas control to protect a
25 molten weld pool from oxidation at elevated temperatures and provide ionized plasma for an arc, and other aspects such as arc stability to control the quality of the weld. These systems are often deployed over great distances in larger manufacturing environments and many times are spread across multiple manufacturing centers. Given the nature and requirements of modern and
30 more complex manufacturing operations however, welding systems designers, architects and suppliers face increasing challenges in regard to upgrading, maintaining, controlling, servicing and supplying various welding locations. Unfortunately, many conventional welding systems operate in individually controlled and somewhat isolated manufacturing locations in regard to the

overall assembly process. Thus, controlling, maintaining, servicing and supplying multiple and isolated locations in large centers, and/or across the globe, has become more challenging, time consuming and expensive.

5 One such challenge relates to facilitating service support of welder(s) and/or welding system(s). Conventionally, service support of welder(s) has occurred *via* an awkward combination of technical manuals and/or bulletins from manufacturers and/or diagnosis of welder(s) by operator(s). As welder(s) become increasing complex they have likewise become increasing difficult to service and/or support leading to increase down time.

10 Further, welder fault(s) and/or alarm(s) have been difficult for operator(s) to monitor and/or initiate corrective action. Conventionally, operator(s) learn of fault(s) and/or alarm(s) when they are in physical proximity of the welder (*e.g.*, by reviewing status indicator(s) and/or monitoring equipment). This can be time-consuming and can lead to
15 inconsistent result based upon an operator's level of experience.

SUMMARY

20 The following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. It is not intended to identify key or critical elements of the invention or to delineate the scope of the invention. Its sole purpose is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is presented later.

25 The present invention relates to a system and method for facilitating welding diagnostics. The present invention provides for a welder to be operatively connected to a local system, a remote system and/or an alarm component. A sensor component of the welder can receive information regarding operation of the welder and/or weld characteristics through test
30 equipment and/or monitoring equipment. A control component of the welder can execute test sequence(s) based, at least in part, upon information received from the sensor component to facilitate welding system diagnostics. Information from the sensor component and/or the control component can be received by a diagnostic component that can perform internal diagnostics.

Based, at least in part, upon information received from the sensor component, control component and/or internal diagnostics, the diagnostics component can determine a health status of the welder and/or whether the welder has any functional and/or performance problems (*e.g.*, alarm(s) and/or fault(s)). The welder can communicate the health status of the welder, welder data and/or whether the welder has functional and/or performance problems to the local system, the remote system and/or the alarm component (*e.g.*, *via* voicemail, telephone, e-mail and/or beeper). Information regarding the health status of the welder, functional and/or performance problems can further be stored in an event log.

Accordingly to another aspect of the present invention, the remote system can have an expert component for facilitating welding diagnostics. The expert component can employ various artificial intelligence technique(s) (*e.g.*, Bayesian model, probability tree network, fuzzy logic and/or neural network) to facilitate welding diagnostics based, at least in part, upon the welder data and/or health status received from the welder. The expert component can adaptively modify its modeling technique(s) based upon historical success (*e.g.*, learn from success of previous welding diagnostics).

Yet another aspect of the present invention provides for the expert component to access an expert data store, a local service support data store, a remote expert data store and/or a remote service support data store to facilitate welding diagnostics. The expert data store and/or the remote expert data store can store information associated with welding diagnostics (*e.g.*, current expert system rules, diagrams, welder troubleshooting procedure(s) and/or welder software upgrade(s)) that the expert component can utilize to facilitate welding diagnostics. The local service support data store and/or the remote service support data store can store information (*e.g.*, welder service record, welder part order information, welder warranty information and/or welder service information) that the expert component can utilize to facilitate welding diagnostics.

According to an aspect of the present invention, the welder, local system and/or remote system can initiate corrective action, at least temporarily, based, at least in part, upon the health status of the welder. Further, the welder can communicate with the local system and/or the remote

system (*e.g.*, via voicemail, telephone, e-mail and/or beeper) to schedule maintenance (*e.g.*, based upon usage of the welder).

The following description and the annexed drawings set forth in detail certain illustrative aspects of the invention. These aspects are indicative, however, of but a few of the various ways in which the principles of the invention may be employed and the present invention is intended to include all such aspects and their equivalents. Other advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a welding diagnostics system in accordance with an aspect of the present invention.

Fig. 2 is a block diagram of a welding diagnostics system in accordance with an aspect of the present invention.

Fig. 3 is a table of simulated errors and/or alarms generated in accordance with an aspect of the present invention.

Fig. 4 is a simulated screen shot of a user interface in accordance with an aspect of the present invention.

Fig. 5 is a block diagram of a welding diagnostics system in accordance with an aspect of the present invention.

Fig. 6 is a block diagram of a welding diagnostics system in accordance with an aspect of the present invention.

Fig. 7 is a block diagram of a welding diagnostics system in accordance with an aspect of the present invention.

Fig. 8 is a flow diagram illustrating a methodology for providing welding diagnostics in accordance with an aspect of the present invention.

Fig. 9 is a flow diagram illustrating a methodology for providing welding diagnostics in accordance with an aspect of the present invention.

DESCRIPTION OF THE INVENTION

The present invention is now described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific

details are set forth in order to provide a thorough understanding of the present invention. It may be evident to one skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to facilitate description of the present invention.

As used in this application, "system" is a structure comprising one or more components. A "component" is a structure comprising computer hardware and/or software. For example, a component can be, but is not limited to, a computer readable memory encoded with software instructions or a computer configured to carry out specified tasks. By way of illustration, both an application program stored in computer readable memory and a server on which the application runs can be components. Due to the nature of components, multiple components can be intermingled and are often not separate from one another. Systems can likewise be intermingled and inseparable. Further, "extranet" refers to a network of trusted trading partners communicating securely *via* a network that can be, but is not limited to, the Internet, a local area network, a computer network, an Intranet, a wide area network, a virtual private network, a metropolitan area network, and a wireless network.

A "welder" refers to physical hardware for producing a weld such as a wire feeder, contact tip, dresser, gas mixer, gas sneezer, gas controller, clamp actuator, travel carriage/part manipulator, robot arm/beam/torch manipulator, laser seam tracker, other input/output devices and welding power source along with any controller(s), monitor(s) and communications interface(s) associated with the physical hardware. For example, a welder can be used to perform gas metal arc welding (MIG), flux cored arc welding, metal cored arc welding, submerged arc welding (SAW), narrow groove welding, hot wire filled gas tungsten arc (TIG) welding, cold wire filled TIG welding, plasma arc welding, electron beam and laser welding, hardface welding, arc gauging and manual shielded arc welding (stick welding).

Referring to Fig. 1, a welding diagnostics system 100 in accordance with an aspect of the present invention is illustrated. The welding diagnostics system 100 includes a welder 110 having a network interface 120, a sensor component 130, a control component 140 and a diagnostic component 150.

The network interface 120 can operatively couple the welder 110 to a remote system 160 *via* a network 162. For example, the network 162 can employ Ethernet (IEEE 802.3), Wireless Ethernet (IEEE 802.11), PPP (point-to-point protocol), point-to-multipoint short-range RF (Radio Frequency),
5 WAP (Wireless Application Protocol), Bluetooth, IP, IPv6, TCP and User Datagram Protocol (UDP). Further, the network connection can be *via* an extranet. For example, the network connection can be *via* a phone connection (not shown) from the network interface 120 to an Internet Service Provider (ISP) to the remote system 160. Another possible network connection is *via* a
10 Local Area Network (LAN) to the remote system 160. It is noted that the welder 110 and associated welding equipment (not shown) can communicate over a separate and isolated network from the network 162 (*e.g.*, Arclink). Information exchanged between and among the welder 110 and the remote system 160 can be in a variety of formats and can include, but is not limited to,
15 such technologies as HTML, SHTML, VB Script, JAVA, CGI Script, JAVA Script, dynamic HTML, PPP, RPC, TELNET, TCP/IP, FTP, ASP, XML, PDF, EDI, WML as well as other formats.

The sensor component 130 is adapted to receive information associated with operation of the welder 110 (*e.g.*, voltage and/or current levels) and/or
20 characteristic(s) of weld(s) produced by the welder 110 (*e.g.*, image of weld(s)). The sensor component 130 can receive information from monitoring equipment 170 (*e.g.*, digital camera and/or streaming video camera image(s) of weld(s)) and/or test equipment 180 (*e.g.*, ohm meter, voltage meter and/or current meter).

25 The control component 140 is adapted to receive information from the sensor component 130 and can perform test sequence(s) to facilitate diagnostics of the welder 110 based, at least in part, upon information received from the sensor component 130.

The diagnostics component 150 is adapted to receive information from
30 the sensor component 130 and/or the control component 140. Further, the diagnostic component 150 can receive diagnostic information associated with component(s) and/or system(s) internal to the welder 110 (*e.g.*, printed circuit board(s)). The diagnostic component 150 can perform resident diagnostic modes with regard to the component(s) and/or system(s) internal to the welder

110. The diagnostic component 150 can initiate test sequence(s) to facilitate diagnostics of the welder 110 based at least in part upon information received from the sensor component 130, the control component 150 and/or internal diagnostics.

5 Based, at least in part, upon information received from the sensor component 130, the control component 140 and/or internal diagnostics, the diagnostic component can determine a health status of the welder 110. The health status of the welder can include, but is not limited to, information associated with functional and/or performance test results of the welder,
10 error(s) and/or alarm(s). The diagnostic component 150 can send information associated with the health status of the welder 110 to the remote system 160 *via* the network interface 120. Further, the diagnostic component 150 can initiate corrective action based, at least in part, upon information received from the sensor component 130, the control component 140 and/or internal
15 diagnostics. For example, if the diagnostic component 150 determines that secondary current of the welder 110 has exceeded a threshold for current (*e.g.*, 150 amps), the diagnostic component 150 can, at least temporarily, initiate a reduction in welder current (*e.g.*, 50 amps) until the diagnostic component 150 determines that the condition has been corrected and/or the diagnostic
20 component 150 has been overridden (*e.g.*, by operator instruction).

 The welder 110 can further include a communications component 190 facilitating communication between the welder 110 and the remote system 160. The communications component 190 can receive information associated with the health status of the welder (*e.g.*, an alarm condition) and format the
25 information for use by the remote system 160 (*e.g.*, HTML document). The communications component 190 can dynamically provide information regarding the health status of the welder to the remote system in a plurality of format(s) within the scope of the present invention (*e.g.*, *via* dynamic HTML, RTF and/or ASCII text). For example, based upon the health status of the
30 welder, the communications component 190 can dynamically create an HTML file for transmission to the remote system 160 (*e.g.*, using CGI scripts, Java or JavaScript). Further, the welder 110 can communicate with the remote system 160 (*e.g.*, *via* voicemail, telephone, e-mail and/or beeper) to schedule maintenance (*e.g.*, based upon usage of the welder).

The network interface 120 can include a web server 122 that provides information exchange with the remote system 160. The welder 110 can further include a web pages database 124 and a welder data store 128. The web pages database 124 can store information associated with welding diagnostics stored on the remote system 160 accessible *via* the network interface 120. For example, the web pages database 124 can provide hyperlinks to welding diagnostic resource(s) available *via* the Internet to an operator of the welder 110 (*e.g.*, accessible *via* the web server 122). Further, information regarding the health status of the welder can be exchanged *via* web pages and/or information stored in the web pages database 124.

The welder data store 128 can store information associated with the welder 110 (*e.g.*, welder serial number, welder model number, welder build date and/or welder software version identifier) and/or information associated with component part(s) of the welder 110 (*e.g.*, component part identifier(s), component version identifier(s) and/or component software version identifier(s)). Information associated with the welder 110 stored in the welder data store 128 can be transmitted *via* the network interface 120 to the remote system 160. For example, the remote system 160 can query the welder data store 128 for information associated with a component printed circuit board to determine a software version number to facilitate the remote system 160 in determining likely cause(s) of welder fault(s) and/or alarm(s).

Turning to Fig. 2, a welding diagnostics system 200 in accordance with an aspect of the present invention is illustrated. The welding diagnostics system 200 includes a welder 210 having a network interface 220, a sensor component 230, a control component 240, an event component 250 and an event log 260. The welder can further have a communications component 270.

The network interface 220 can operatively couple the welder 210 to an alarm component 290 *via* a network 222. For example, the network 222 can employ Ethernet (IEEE 802.3), Wireless Ethernet (IEEE 802.11), PPP (point-to-point protocol), point-to-multipoint short-range RF (Radio Frequency), WAP (Wireless Application Protocol), Bluetooth, IP, IPv6, TCP and User Datagram Protocol (UDP). Further, the network connection can be *via* an extranet. For example, the network connection can be *via* a phone connection

(not shown) from the network interface 220 to an Internet Service Provider (ISP) to the alarm component 290. Another possible network connection is via a Local Area Network (LAN) to the alarm component 290. It is noted that the welder 210 and associated welding equipment (not shown) can communicate over a separate and isolated network from the network 222 (e.g., Arclink). Information exchanged between and among the welder 210 and the alarm component 290 can be in a variety of formats and can include, but is not limited to, such technologies as HTML, SHTML, VB Script, JAVA, CGI Script, JAVA Script, dynamic HTML, PPP, RPC, TELNET, TCP/IP, FTP, ASP, XML, PDF, EDI, WML as well as other formats.

The sensor component 230 is adapted to receive information associated with operation of the welder 210 (e.g., voltage and/or current levels) and/or characteristic(s) of weld(s) produced by the welder 210 (e.g., image of weld). The sensor component 230 can receive information from monitoring equipment (not shown) (e.g., digital camera and/or streaming video camera image(s) of weld(s)) and/or test equipment (not shown) (e.g., ohm meter, voltage meter and/or current meter).

The control component 240 is adapted to receive information from the sensor component 230 and/or the control component and to perform test sequence(s) to facilitate diagnostics of the welder 210 based at least in part upon information received from the sensor component 230. For example, upon receiving an unexpected indication of low resistance (e.g., possibly indicative of a short circuit), the control component 240 can execute test sequence(s) to assist in determining a cause of the indication (e.g., external problem such as a shorted connection and/or internal problem such as a failed welder component). The control component 240 can further receive diagnostic information associated with component(s) and/or system(s) internal to the welder 210 (e.g., printed circuit board(s)). The control component 240 can perform resident diagnostic modes with regard to the component(s) and/or system(s) internal to the welder 210. The control component 240 can perform test sequence(s) to facilitate diagnostics of the welder 210 based at least in part upon information received from the sensor component 230 and/or internal diagnostics.

The event component 250 is adapted to receive information from the sensor component 230 and/or the control component 240. Based, at least in part, upon information received from the sensor component 230, the control component 240 and/or internal diagnostics, the event component 250
5 determines the occurrence of welder event(s) (*e.g.*, fault and/or alarm condition). The event component 250 can store information associated with welder event(s) in an event log 260 (*e.g.*, fault and/or alarm, code number, description of event, suggested corrective action and/or time-stamp of event(s)). The event component 250 can send information associated with
10 welder event(s) to the network interface 220 for communication to an alarm component 290 (*e.g.*, fault and/or alarm, code number, description of event, apparent problem, suggested corrective action and/or time-stamp of event).

Information associated with welder event(s) stored in the event log 260 can be available for review by an operator (*e.g.*, *via* a video display terminal)
15 and/or remote system (not shown). Information stored in the event log 260 can be stored in a variety of data structures including, but not limited to, lists, arrays and/or databases. Referring to Fig. 3, a table of simulated errors and/or alarms generated in accordance with an aspect of the present invention is illustrated.

20 Turning to Fig. 4, simulated screen shots 410 and 420 of a user interface in accordance with an aspect of the present invention are illustrated. Simulated screen shot 410 graphically depicts information stored in the event log 260. Simulated screen shot 410 has three event entries having an entry number, event code, time stamp, two data fields and a description field.
25 Simulated screen shot 410 further provides an apparent problem and suggested action (*e.g.*, determined by the event component 250, control component 240, diagnostic component 150, remote system 160 and/or alarm component 290).

Simulated screen shot 420 graphically depicts information stored in an event log 260. Simulated screen shot 420 has one entry having an entry
30 number, event code, time stamp, two data fields and a description field. Simulated screen shot 420 also provides an apparent problem and suggested action (*e.g.*, determined by the event component 250, control component 240, diagnostic component 150, remote system 160 and/or alarm component 290).

Simulated screen shots 410 and 420 illustrate information that may be available to a user, remote system and/or alarm component based upon information stored, for example, in the event log 260. It is to be appreciated that additional or less information may be made available to a user, remote
5 system and/or alarm component regarding welder event(s) in accordance with the present invention.

Turning back to Fig. 2, the welder 210 can further include a communications component 270 facilitating communication between the welder 210 and the alarm component 290. The communications component
10 270 can receive information associated with welder event(s) (e.g., alarm(s), fault(s), functional test result(s) and/or performance test result(s)) and format the information for transmission to the alarm component 290 (e.g., Dynamic HTML, rich-text format or ASCII text). The welder 210 can further include a communications data store 272 storing information regarding how to handle
15 particular fault(s) and/or alarm(s). Based upon information stored in the communications data store 272, the communications component 270 can determine a mode (e.g., voicemail number, e-mail address, telephone number and/or beeper number) for notification that alarm and/or fault event(s) have occurred.

20 The network interface 220 can further include a SMTP component 282 for transmitting and/or receiving email regarding welder health status. For example, the SMTP component 282 can receive a request from the alarm component 290 (e.g., Internet enabled personal digital assistant) for information stored in the event log 260. Responding to the request, the SMTP
25 component 282 can request information stored in the event log 260 *via* the communications component 270. It is to be appreciated that the communications component 270 can retrieve particular information requested (e.g., most recent alarm/fault) and/or transmit substantially all information stored in the event log 260. The communications component 270 can format
30 information stored in the event log 260 for transmission by the SMTP component 282 to the alarm component 290. The network interface 220 can further include a web server 280 facilitating information exchange with the alarm component 290 (e.g., computer system, beeper, telephone, personal digital assistant).

Next, referring to Fig. 5, a welding diagnostics system 500 in accordance with an aspect of the present invention is illustrated. The welding diagnostic system 500 includes a welder 510 having a network interface 530, a sensor component 538, a control component 536, a diagnostic component 534, a communications component 532 and a welder data store 520. The welder 510 can further include an event log 522.

The welder 510 and a local system 580 are operatively coupled *via* a first network 512. For example, the first network 512 can employ Ethernet (IEEE 802.3), Wireless Ethernet (IEEE 802.11), PPP (point-to-point protocol), point-to-multipoint short-range RF (Radio Frequency), WAP (Wireless Application Protocol), Bluetooth, IP, IPv6, TCP and User Datagram Protocol (UDP). Information exchanged between and among the local system 580 and the welder 510 can be in a variety of formats and can include, but is not limited to, such technologies as HTML, SHTML, VB Script, JAVA, CGI Script, JAVA Script, dynamic HTML, PPP, RPC, TELNET, TCP/IP, FTP, ASP, XML, PDF, EDI, WML as well as other formats.

The sensor component 538 is adapted to receive information associated with operation of the welder 510 (*e.g.*, voltage and/or current levels) and/or weld characteristic(s) of weld(s) produced by the welder 510 (*e.g.*, image(s) of weld(s)). The sensor component 538 and/or the local system 580 can receive information from monitoring equipment 550 (*e.g.*, digital camera and/or streaming video camera image(s) of weld(s)) and/or test equipment 570 (*e.g.*, ohm meter, voltage meter and/or current meter). It is to be appreciated that the monitoring equipment 550 and/or test equipment 570 can be operatively coupled to the welder 510 and/or the local system 580.

The control component 536 is adapted to receive information from the sensor component 538 and to perform test sequence(s) to facilitate diagnostics of the welder 510 based, at least in part, upon information received from the sensor component 538.

The diagnostic component 534 is adapted to receive information from the sensor component 538 and/or the control component 536. The diagnostic component 534 can further receive diagnostic information associated with component(s) and/or system(s) internal to the welder 510 (*e.g.*, printed circuit board(s)). The diagnostic component 534 can perform resident diagnostic

mode(s) with regard to the component(s) and/or system(s) internal to the welder 510. Based, at least in part, upon information received from the sensor component 538, the control component 536 and/or internal diagnostics, the diagnostic component 534 determines health status of the welder 510. The health status of the welder can include, but is not limited to, information associated with functional and/or performance test results of the welder, error(s) and/or alarm(s). The diagnostic component 534 can send information associated with the health status of the welder 510 to the local system 580 *via* the network interface 530. Further, the diagnostic component 534 can initiate corrective action based at least in part upon information received from the sensor component 538 and/or the control component 536.

The welder 510 can further include a communications component 532 facilitating communications between the welder 510 and the local system 580. The communications component 532 can receive information associated with the health status of the welder (*e.g.*, an alarm condition) and format the information for use by the local system 580 (*e.g.*, HTML document). Thus, the communications component 532 can dynamically provide information regarding the health status of the welder to the local system 580 in a plurality of format(s) within the scope of the present invention (*e.g.*, *via* dynamic HTML, RTF and/or ASCII text). For example, based upon the health status of the welder, the communications component 532 can dynamically create an HTML file for transmission to the local system 580 (*e.g.*, using CGI scripts, Java or JavaScript). Further, the welder 510 can communicate with the local system 580 (*e.g.*, *via* voicemail, telephone, e-mail and/or beeper) to schedule maintenance (*e.g.*, based upon usage of the welder). Information associated with the health status of the welder 510 (*e.g.*, alarm(s) and/or fault(s)) can be stored in the event log 522.

The welder data store 520 can provide information associated with the welder 510 (*e.g.*, welder serial number, welder model number, welder build date and/or welder software version identifier) and/or information associated with component part(s) of the welder 510 (*e.g.*, component part identifier(s), component version identifier(s) and/or component software version identifier(s)). Information associated with the welder 510 stored in the welder data store 520 can be transmitted *via* the network interface 530 to the local

system 580. For example, the local system 580 can query the welder data store 520 for information associated with a component printed circuit board to determine a software version number in order to determine a likely cause of a welder fault and/or alarm.

5 The local system 580 can have an expert component 592, an expert data store 594, a local service support data store 586 and a web interface component 588. The expert component 592 can employ various artificial intelligence technique(s) (e.g., Bayesian model, probability tree network, fuzzy logic and/or neural network) to facilitate welding diagnostics based, at
10 least in part, upon the health status received from the welder 510. Further, the expert component 592 can adaptively modify its modeling technique(s) based upon historical success (e.g., learn from success of previous welding diagnostics).

 The expert data store 594 can store information associated with
15 welding diagnostics (e.g., current expert system rules, diagrams, welder troubleshooting procedure(s) and/or welder software upgrade(s)) that the expert component 592 can utilize to facilitate welding diagnostics. The local service support data store 586 can store information (e.g., welder service record, welder part order information, welder warranty information and/or
20 welder service information) that the expert component 592 can utilize to facilitate welding diagnostics.

 The welding diagnostics system 500 can further include a remote expert data store 598 and/or a remote service data store 596 operatively coupled to the web interface component 588 of the local system 580 *via* a
25 second network connection 582. For example, the second network 582 can employ Ethernet (IEEE 802.3), Wireless Ethernet (IEEE 802.11), PPP (point-to-point protocol), point-to-multipoint short-range RF (Radio Frequency), WAP (Wireless Application Protocol), Bluetooth, IP, IPv6, TCP and User Datagram Protocol (UDP). Further, the second network connection can be *via*
30 an extranet. For example, the second network connection can be *via* a phone connection (not shown) from the local system 580 to an Internet Service Provider (ISP) to the remote welding data store 594 and/or the remote service data store 596. Another possible network connection is *via* a Local Area Network (LAN) to the remote expert data store 598 and/or the remote service

data store 596. Information exchanged between and among the local system 580 and the remote expert data store 598 and/or the remote service data store 596 can be in a variety of formats and can include, but is not limited to, such technologies as HTML, SHTML, VB Script, JAVA, CGI Script, JAVA Script, dynamic HTML, PPP, RPC, TELNET, TCP/IP, FTP, ASP, XML, PDF, EDI, WML as well as other formats. It is to be appreciated that the welder 510 and associated welding equipment (not shown) can communicate over a separate and isolated network (*e.g.*, Arclink) from the first network 512 and/or the second network 582.

The remote expert data store 598 can store information associated with welding diagnostics (*e.g.*, current expert system rules, diagrams, welder troubleshooting procedure(s) and/or welder software upgrade(s)) that the expert component 592 can utilize to facilitate welding diagnostics. The remote service data store 596 can store information (*e.g.*, welder service record, welder part order information, welder warranty information and/or welder service information) that the expert component 592 can utilize to facilitate welding diagnostics.

Referring to Fig. 6, a welding diagnostics system 600 in accordance with an aspect of the present invention is illustrated. The welding diagnostic system 600 includes a welder 610 having a network interface 622, a sensor component 612, a control component 614, a diagnostic component 616, a communications component 618 and a welder data store 624. The welder 610 can further include an event log 626.

The welder 610 and a remote system 640 are operatively coupled *via* a network 680. For example, the network 680 can employ Ethernet (IEEE 802.3), Wireless Ethernet (IEEE 802.11), PPP (point-to-point protocol), point-to-multipoint short-range RF (Radio Frequency), WAP (Wireless Application Protocol), Bluetooth, IP, IPv6, TCP and User Datagram Protocol (UDP). Information exchanged between and among the remote system 640 and the welder 610 can be in a variety of formats and can include, but is not limited to, such technologies as HTML, SHTML, VB Script, JAVA, CGI Script, JAVA Script, dynamic HTML, PPP, RPC, TELNET, TCP/IP, FTP, ASP, XML, PDF, EDI, WML as well as other formats.

The sensor component 612 is adapted to receive information associated with operation of the welder 610 (*e.g.*, voltage and/or current levels) and/or characteristic(s) of weld(s) produced by the welder 610 (*e.g.*, image(s) of weld(s)). The sensor component 612 can receive information from monitoring component 620 (*e.g.*, digital camera and/or streaming video camera image(s) of weld(s)) and/or test component 630 (*e.g.*, ohm meter, voltage meter and/or current meter).

The control component 614 is adapted to receive information from the sensor component 612 and to perform test sequence(s) to facilitate diagnostics of the welder 610 based, at least in part, upon information received from the sensor component 612.

The diagnostic component 616 is adapted to receive information from the sensor component 612 and/or the control component 614. The diagnostic component 614 can further receive diagnostic information associated with component(s) and/or system(s) internal to the welder 610 (*e.g.*, printed circuit board(s)). The diagnostic component 616 can perform resident diagnostic mode(s) with regard to the component(s) and/or system(s) internal to the welder 610. Based, at least in part, upon information received from the sensor component 612, the control component 614 and/or internal diagnostics, the diagnostic component 616 determines health status of the welder 610. The health status of the welder can include, but is not limited to, information associated with functional and/or performance test results of the welder, error(s) and/or alarm(s). The diagnostic component 616 can send information associated with the health status of the welder 610 to the remote system 640 *via* the network interface 622. Further, the diagnostic component 616 can initiate corrective action based, at least in part upon information, received from the sensor component 612, the control component 614, internal diagnostics or from the remote system 640. Information associated with the health status of the welder 610 (*e.g.*, alarm(s) and/or fault(s)) can be stored in the event log 626.

The welder 610 can further include a communications component 618 facilitating communications between the welder 610 and the remote system 640. The communications component 618 can receive information associated with the health status of the welder (*e.g.*, an alarm condition) and format the

information for use by the remote system 640 (*e.g.*, HTML document). Thus, the communications component 618 can dynamically provide information regarding the health status of the welder to the remote system 640 in a plurality of format(s) within the scope of the present invention (*e.g.*, *via* dynamic HTML, RTF and/or ASCII text). For example, based upon the health status of the welder, the communications component 618 can dynamically create an HTML file for transmission to the remote system 640 (*e.g.*, using CGI scripts, Java or JavaScript). Further, the welder 610 can communicate with the remote system 640 (*e.g.*, *via* voicemail, telephone, e-mail and/or beeper) to schedule maintenance (*e.g.*, based upon usage of the welder).

The welder data store 624 can provide information associated with the welder 610 (*e.g.*, welder serial number, welder model number, welder build date and/or welder software version identifier) and/or information associated with component part(s) of the welder 610 (*e.g.*, component part identifier(s), component version identifier(s) and/or component software version identifier). Information associated with the welder 610 stored in the welder data store 624 can be transmitted *via* the network interface 622 to the remote system 640. For example, the remote system 640 can query the welder data store 624 for information associated with a component printed circuit board to determine a software version number in order to determine a likely cause of a welder fault and/or alarm.

The remote system 640 can have an expert component 642 and a web interface component 646. The expert component 642 can employ various artificial intelligence technique(s) (*e.g.*, Bayesian model, probability tree network, fuzzy logic and/or neural network) to facilitate welding diagnostics based, at least in part, upon the health status received from the welder 610. The expert component 642 can adaptively modify its modeling technique(s) based upon historical success (*e.g.*, learn from success of previous welding diagnostics). The web interface component 646 can operatively connect the remote system 640 to remote welding resource(s) (*e.g.*, *via* the Internet) and/or the welder 610.

The welding diagnostics system 600 can further include a remote expert data store 650 and/or a remote service support data store 660. The remote expert data store 650 can store information associated with welding

diagnostics (e.g., current expert system rules, diagrams, welder troubleshooting procedure(s) and/or welder software upgrade(s)) that the expert component 642 can access *via* the network 680 to facilitate welding diagnostics. The remote service support data store 660 can store information (e.g., welder service record, welder part order information, welder warranty information and/or welder service information) that the expert component 642 can access *via* the network 680 to facilitate welding diagnostics.

Next, referring to Fig. 7, a welding diagnostics system 700 in accordance with an aspect of the present invention is illustrated. The welding diagnostic system 700 includes a welder 610 having a network interface 622, a sensor component 612, a control component 614, a diagnostic component 616, a communications component 618 and a welder data store 624.

The welder 610 and a remote system 640 are operatively coupled *via* a network 680. The welding diagnostics system 700 further includes monitoring equipment 720 and/or test equipment 730 that are operatively coupled to the remote system 640 and/or the welder 610 *via* the network 680.

The sensor component 612 is adapted to receive information associated with operation of the welder 610 (e.g., voltage and/or current levels) and/or characteristic(s) of weld(s) produced by the welder 610 (e.g., image(s) of weld(s)). The sensor component 612 can receive information from monitoring equipment 720 (e.g., digital camera and/or streaming video camera image(s) of weld(s)) and/or test equipment 730 (e.g., ohm meter, voltage meter and/or current meter) *via* the network 680.

The control component 614 is adapted to receive information from the sensor component 612 and to perform test sequence(s) to facilitate diagnostics of the welder 610 based, at least in part, upon information received from the sensor component 612.

The diagnostic component 616 is adapted to receive information from the sensor component 612 and/or the control component 614. The diagnostic component 616 can further receive diagnostic information associated with component(s) and/or system(s) internal to the welder 610 (e.g., printed circuit board(s)). The diagnostic component 616 can perform resident diagnostic mode(s) with regard to the component(s) and/or system(s) internal to the welder 610. Based, at least in part, upon information received from the sensor

component 612, the control component 614 and/or internal diagnostics, the diagnostic component 616 determines health status of the welder 610. The health status of the welder can include, but is not limited to, information associated with functional and/or performance test results of the welder, error(s) and/or alarm(s). The diagnostic component 616 can send information associated with the health status of the welder 610 to the remote system 640 via the network interface 622. Further, the diagnostic component 616 can initiate corrective action based, at least in part upon information, received from the sensor component 612, the control component 614, internal diagnostics or from the remote system 640.

The welder 610 can further include a communications component 618 facilitating communications between the welder 610 and the remote system 640. The communications component 618 can receive information associated with the health status of the welder (*e.g.*, an alarm condition) and format the information for use by the remote system 640 (*e.g.*, HTML document). Thus, the communications component 618 can dynamically provide information regarding the health status of the welder to the remote system 640 in a plurality of format(s) within the scope of the present invention (*e.g.*, via dynamic HTML, RTF and/or ASCII text).

The remote system 640 can have an expert component 642 which can employ various artificial intelligence technique(s) (*e.g.*, Bayesian model, probability tree network, fuzzy logic and/or neural network) to facilitate welding diagnostics based, at least in part, upon the health status received from the welder 610. The expert component 642 can adaptively modify its modeling technique(s) based upon historical success (*e.g.*, learn from success of previous welding diagnostics).

The welding diagnostics system 600 can further include a remote expert data store 650 and/or a remote service support data store 660. The remote expert data store 650 can store information associated with welding diagnostics (*e.g.*, current expert system rules, diagrams, welder troubleshooting procedure(s) and/or welder software upgrade(s)) that the expert component 642 can access via the network 680 to facilitate welding diagnostics. The remote service support data store 660 can store information (*e.g.*, welder service record, welder part order information, welder warranty

information and/or welder service information) that the expert component 642 can access *via* the network 680 to facilitate welding diagnostics.

Figs. 8 and 9 illustrate methodologies for providing various aspects of a welding diagnostics system in accordance with the present invention. The methods comprise a group of actions or processes represented by blocks.

While, for purposes of simplicity of explanation, the methodologies are shown and described as a series of blocks, it is to be understood and appreciated that the present invention is not limited by the number or order of blocks, as some blocks may, in accordance with the present invention, occur in different orders and/or concurrently with other blocks from that shown and described herein.

For example, those skilled in the art will understand and appreciate that a methodology could alternatively be represented as a series of interrelated states, such as in a state diagram. Moreover, not all illustrated acts may be required to implement a methodology in accordance with the present invention.

Turning to Fig. 8, a methodology 800 for welding system diagnostics is illustrated. At 810, sensor input(s) are received. At 820, test sequence(s) are performed, based at least in part upon the sensor input(s). At 830, diagnostics are performed on internal component(s) and/or system(s). At 840, a determination is made as to whether any alarm and/or fault condition(s) exist. If the determination at 840 is NO, no further processing occurs. If the determination at 840 is YES, at 850, the alarm and/or fault event(s) are logged (*e.g.*, to an event log). At 860, a message is sent to a remote system regarding the alarm and/or fault condition(s) (*e.g.*, *via* voicemail, telephone, e-mail and/or beeper).

Next, referring to Fig. 9, a methodology 900 for welding system diagnostics is illustrated. At 910, sensor input(s) are received. At 920, information is received from test equipment and/or monitoring equipment. At 930, information is received from the welder. At 940, diagnostics are performed based at least in part upon the sensor input(s), information received from test equipment and/or monitoring equipment and information received from the welder. At 950, information is sent regarding health status of the welder (*e.g.*, to a local system and/or remote system). Next, at 960, a determination is made as to whether an alarm and/or fault condition exists. If

- the determination at 960 is NO, no further processing occurs. If the
- determination at 960 is YES, at 970, corrective action is initiated.

- What has been described above are various aspects of the present
- invention. It is, of course, not possible to describe every conceivable
5 combination of components or methodologies for purposes of describing the
present invention, but one of ordinary skill in the art will recognize that many
further combinations and permutations of the present invention are possible.
Accordingly, the present invention is intended to embrace all such alterations,
modifications and variations that fall within the spirit and scope of the
10 appended claims.

Claims

What is claimed is:

1. A welding system, comprising:
 - a sensor component (130, 230, 538, 612) adapted to receive information associated with at least one of operation of a welder (110, 210, 510, 610) and weld characteristics;
 - a control component (140, 240, 536, 614) adapted to receive information from the sensor component (130, 230, 538, 612) and to perform at least one test sequence to facilitate welder diagnostics based at least in part upon information received from the sensor component (130, 230, 538, 612);
 - a diagnostic component (150, 534, 616) adapted to perform welder internal diagnostics and to receive information from at least one of the sensor component (130, 230, 538, 612) and the control component (140, 240, 536, 614), the diagnostic component (150, 534, 616) determining a health status of welder (110, 210, 510, 610) based at least in part upon information received from at least one of the sensor component (130, 230, 538, 612), the control component (140, 240, 536, 614) and the welder internal diagnostics, the diagnostic component (150, 534, 616) sending information associated with the health status of the welder (110, 210, 510, 610) to a remote system (160, 640).
2. The welding system of claim 1, further comprising a communications component (190, 270, 532, 618) facilitating communications between the welder (110, 210, 510, 610) and the remote system (160, 640) *via* at least one of Dynamic HTML, HTML, SHTML, VB Script, JAVA, CGI Script, JAVA Script, dynamic HTML, PPP, RPC, TELNET, TCP/IP, FTP, ASP, XML, PDF, EDI and WML formats.
3. The system of claim 2, the communications component (190, 270, 532, 618) dynamically creating at least one HTML page associated with the health status of the welder (110, 210, 510, 610).

4. The welding system of claim 1, the sensor component (130, 230, 538, 612) further adapted to receive information associated with the at least one of operation of the welder (110, 210, 510, 610) and weld characteristics from at least one of test equipment (180, 570, 630, 730) and monitoring equipment (170, 550, 620, 720).
5. The welding system of claim 4, the control component (140, 240, 536, 614) further adapted to send information to the at least one of test equipment (180, 570, 630, 730) and monitoring equipment (170, 550, 620, 720) to facilitate welder diagnostics.
6. The welding system of claim 4, the test equipment (180, 570, 630, 730) being at least one of an ohm meter, a voltage meter and a current meter.
7. The welding system of claim 4, the monitoring equipment (170, 550, 620, 720) being at least one of a digital camera and a streaming video camera.
8. The welding system of claim 1, further comprising a web pages database (124) storing links to welding diagnostic resources.
9. The welding system of claim 1, further comprising a welder data store (128, 520, 624) storing at least one of welder serial number, welder model number, welder build date, welder software version identifier, component part identifier, component version identifier and component software version identifier.
10. The welding system of claim 1, the welder (110, 210, 510, 610) and the remote system (160, 640) operatively coupled *via* at least one of a local network, an extranet and the Internet.
11. The welding system of claim 1, the welder (110, 210, 510, 610) further comprising at least one of a web server, an HTTP server and an SMTP server.
12. The welding system of claim 1, the welder (110, 210, 510, 610) sending a message associated with the health status of the welder (110, 210, 510, 610) to the remote system (160, 640) *via* at least one of voicemail, e-mail, telephone, and beeper.

13. The welding system of claim 12, further comprising an event component (250) facilitating reporting of an alarm condition, the message further comprising information associated with the alarm condition.

14. The welding system of claim 13, the event component further storing information associated with the alarm condition in an event log (260, 522, 626).

15. The welding system of claim 12, further comprising a communications data store (272) storing information associated with communicating the message, the communications data store (272) having at least one of telephone number, e-mail address and beeper number.

16. The welding system of claim 1, the welder (110, 210, 510, 610) sending a request to schedule maintenance to the remote system (160, 640) *via* at least one of voicemail, e-mail, telephone and beeper.

17. A system for facilitating welding system diagnostics, comprising:

a welder (110, 210, 510, 610) having a network interface (162, 222, 512, 680) to facilitate communication between the welder (110, 210, 510, 610) and a local system (580);

a sensor component (130, 230, 538, 612) adapted to receive information associated with at least one of operation of the welder (110, 210, 510, 610) and weld characteristics;

a control component (140, 240, 536, 614) adapted to receive information from the sensor component (130, 230, 538, 612) and to perform at least one test sequence to facilitate welder diagnostics based at least in part upon information received from the sensor component (130, 230, 538, 612); and,

a diagnostic component (150, 534, 616) adapted to perform welder internal diagnostics and to receive information from at least one of the sensor component (130, 230, 538, 612) and the control component (140, 240, 536, 614), the diagnostic component (150, 534, 616) determining a health status of the welder (110, 210, 510,

610) based at least in part upon information received from at least one of the sensor component (130, 230, 538, 612), the control component (140, 240, 536, 614) and the welder internal diagnostics, the diagnostic component (150, 534, 616) sending information associated with the health status of the welder (110, 210, 510, 610) to the local system (580) *via* the network interface (162, 222, 512, 680),

wherein the local system (580) has an expert component (592, 642), the expert component (592, 642) receiving information associated with the health status of the welder (110, 210, 510, 610) and facilitating welding diagnostics.

18. The system of claim 17, the welder (110, 210, 510, 610) further comprising a communications component (190, 270, 532, 618) facilitating communications between the welder (110, 210, 510, 610) and the local system (580) *via* at least one of Dynamic HTML, HTML, SHTML, VB Script, JAVA, CGI Script, JAVA Script, dynamic HTML, PPP, RPC, TELNET, TCP/IP, FTP, ASP, XML, PDF, EDI and WML formats *via* the network interface (162, 222, 512, 680).

19. The system of claim 18, the communications component (190, 270, 532, 618) dynamically creating at least one HTML page associated with the health status of the welder (110, 210, 510, 610).

20. The welding system of claim 17, at least one of the sensor component (130, 230, 538, 612) and the local system (580) further adapted to receive information associated with the at least one of operation of the welder (110, 210, 510, 610) and weld characteristics from at least one of test equipment (180, 570, 630, 730) and monitoring equipment (170, 550, 620, 720).

21. The welding system of claim 17, the welder (110, 210, 510, 610) and the local system (580) operatively coupled *via* at least one of a local network, an extranet and the Internet.

22. The welding system of claim 17, the network interface (162, 222, 512, 680) further comprising at least one of a web server, an HTTP server and an SMTP server.

23. The system of claim 17, the expert component (592, 642) further adapted to facilitate welding diagnostics using at least one of a Bayesian model, a probability tree network, a fuzzy logic model and a neural network.
24. The system of claim 17, the local system (580) further comprising a local service support data store (586) storing information with welders comprising at least one of welder service record, welder part order information, welder warranty information and welder service information, the expert component (592, 642) utilizing information stored in the local service support data store (586) to facilitate welding diagnostics.
25. The system of claim 17, the local system (580) further comprising expert data store (594) storing information associated with welding diagnostics comprising at least one of expert system rules, diagrams, welder troubleshooting procedures and welder software, the expert component (592, 642) utilizing information stored in the expert data store (594) to facilitate welding diagnostics.
26. The system of claim 17, the local system (580) further operatively coupled via a second network (582) to at least one of a remote service data store (596, 660) and a remote expert data store (598, 650), the expert component (592, 642) utilizing information stored in the at least one of remote service data store (596, 660) and remote expert data store (598, 650) to facilitate welding diagnostics.
27. A system for facilitating welding system diagnostics, comprising:
- a welder (110, 210, 510, 610) having a network interface (162, 222, 512, 680) to facilitate communication between the welder (110, 210, 510, 610) and a remote system (160, 640);
 - a sensor component (130, 230, 538, 612) adapted to receive information associated with at least one of operation of the welder (110, 210, 510, 610) and weld characteristics;

a control component (140, 240, 536, 614) adapted to receive information from the sensor component (130, 230, 538, 612) and to perform at least one test sequence to facilitate welder diagnostics based at least in part upon information received from the sensor component (130, 230, 538, 612); and,

a diagnostic component (150, 534, 616) adapted to perform welder internal diagnostics and to receive information from at least one of the sensor component (130, 230, 538, 612) and the control component (140, 240, 536, 614), the diagnostic component (150, 534, 616) determining a health status of the welder (110, 210, 510, 610) based at least in part upon information received from at least one of the sensor component (130, 230, 538, 612), the control component (140, 240, 536, 614) and the welder internal diagnostics, the diagnostic component (150, 534, 616) sending information associated with the health status of the welder (110, 210, 510, 610) to the remote system (160, 640) *via* the network interface (162, 222, 512, 680),

wherein the remote system (160, 640) has an expert component (592, 642), the expert component (592, 642) receiving information associated with the health status of the welder (110, 210, 510, 610) and facilitating welding diagnostics.

28. The system of claim 27, the welder (110, 210, 510, 610) further comprising a communications component (190, 270, 532, 618) facilitating communications between the welder (110, 210, 510, 610) and the remote system (160, 640) *via* at least one of Dynamic HTML, HTML, SHTML, VB Script, JAVA, CGI Script, JAVA Script, dynamic HTML, PPP, RPC, TELNET, TCP/IP, FTP, ASP, XML, PDF, EDI and WML formats *via* the network interface (162, 222, 512, 680).

29. The system of claim 28, the communications component (190, 270, 532, 618) dynamically creating at least one HTML page associated with the health status of the welder (110, 210, 510, 610).

30. The welding system of claim 27, at least one of the sensor component (130, 230, 538, 612) and the remote system (160, 640) further adapted to receive information associated with the at least one of operation of the welder (110, 210, 510,

610) and weld characteristics from at least one of test equipment (180, 570, 630, 730) and monitoring equipment (170, 550, 620, 720).

31. The welding system of claim 27, the welder (110, 210, 510, 610) and the remote system (160, 640) operatively coupled *via* at least one of a local network, an extranet and the Internet.

32. The system of claim 27, the expert component (592, 642) further adapted to facilitate welding diagnostics using at least one of a Bayesian model, a probability tree network, a fuzzy logic model and a neural network.

33. The system of claim 27, further comprising a remote service support data store (596, 660) storing information associated with welders comprising at least one of welder service record, welder part order information, welder warranty information and welder service information, the remote service support data store (596, 660) operatively coupled to the remote system (160, 640), the expert component (592, 642) utilizing information stored in the remote service support data store (596, 660) to facilitate welding diagnostics.

34. The system of claim 27, further comprising a remote expert data store (598, 650) storing information associated with welding diagnostics comprising at least one of expert system rules, diagrams, welder troubleshooting procedures and welder software, the remote expert data store (598, 650) operatively coupled to the remote system (160, 640), the expert component (592, 642) utilizing information stored in the expert data store (598, 650) to facilitate welding diagnostics.

35. The system of claim 27, further comprising at least one of test equipment (180, 570, 630, 730) and monitoring equipment (170, 550, 620, 720) operatively coupled to at least one of the welder (110, 210, 510, 610) and the remote system (160, 640).

36. A method for facilitating welding diagnostics, comprising:
- receiving at least one sensor input;
 - determining whether an alarm or fault condition exists; and,
 - sending a message to a remote system (160, 640) regarding the alarm or fault condition if an alarm or fault condition exists.
37. The method of claim 36, further comprising at least one of the following acts:
- performing at least one test sequence based at least in part upon the sensor input;
 - receiving information from at least one of test equipment (180, 570, 630, 730) and monitoring equipment (170, 550, 620, 720);
 - performing diagnostics on at least one internal component;
 - logging the alarm or fault condition if an alarm or fault condition exists; and,
 - initiating corrective action if an alarm or fault condition exists.
38. A system for managing welding information, comprising:
- means for receiving at least one sensor input;
 - means for determining whether an alarm or fault condition exists;
 - means for sending a message to a remote system (160, 640) regarding the alarm or fault condition if an alarm or fault condition exists.
39. A computer-readable medium having computer-executable instructions for executing at least a portion of the method of claim 36.
40. A signal for communicating between welding systems, comprising:
- a signal for communicating between a remote system (160, 640) and a welder (110, 210, 510, 610), the signal having information associated with a health status of the welder (110, 210, 510, 610).

1/9

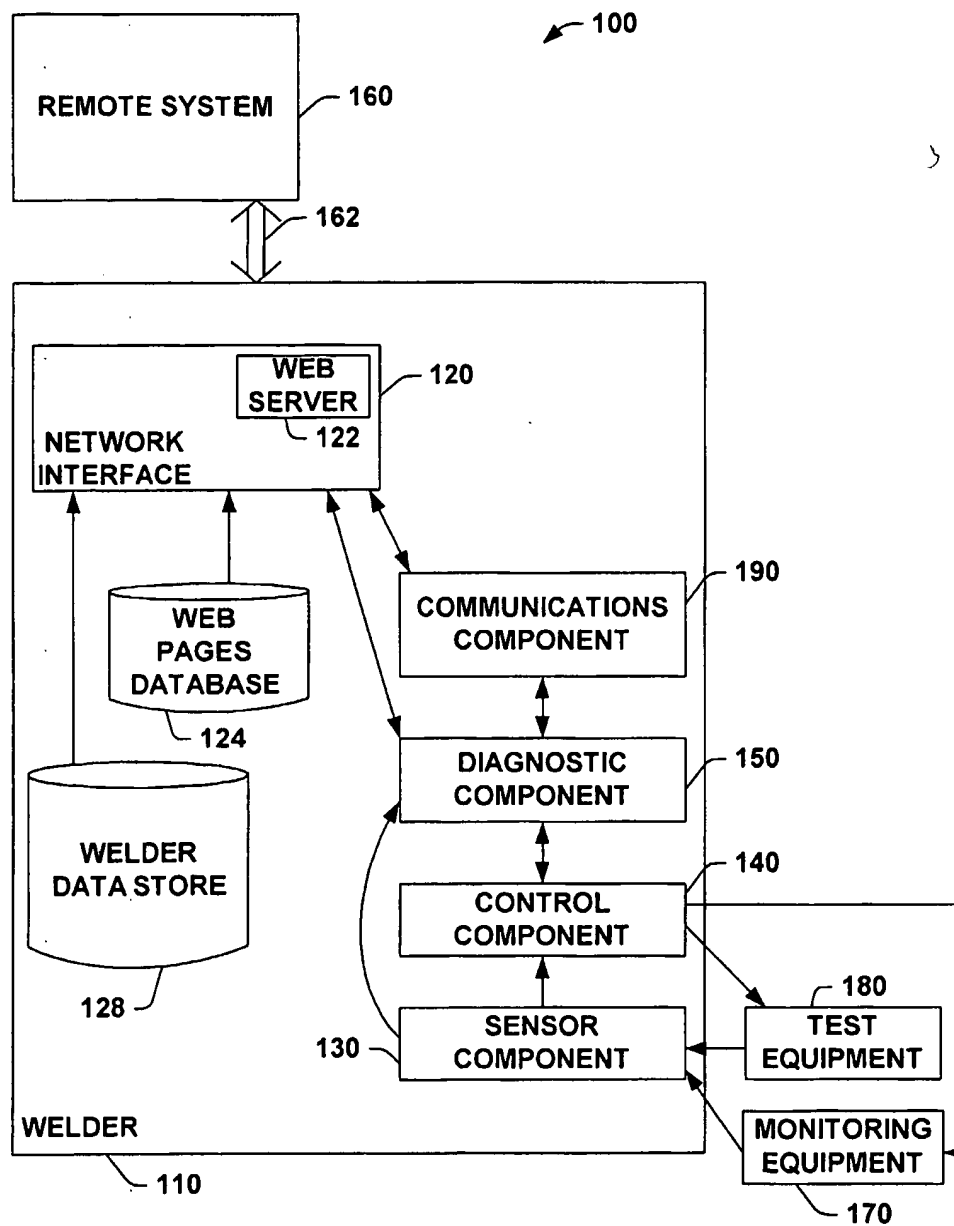
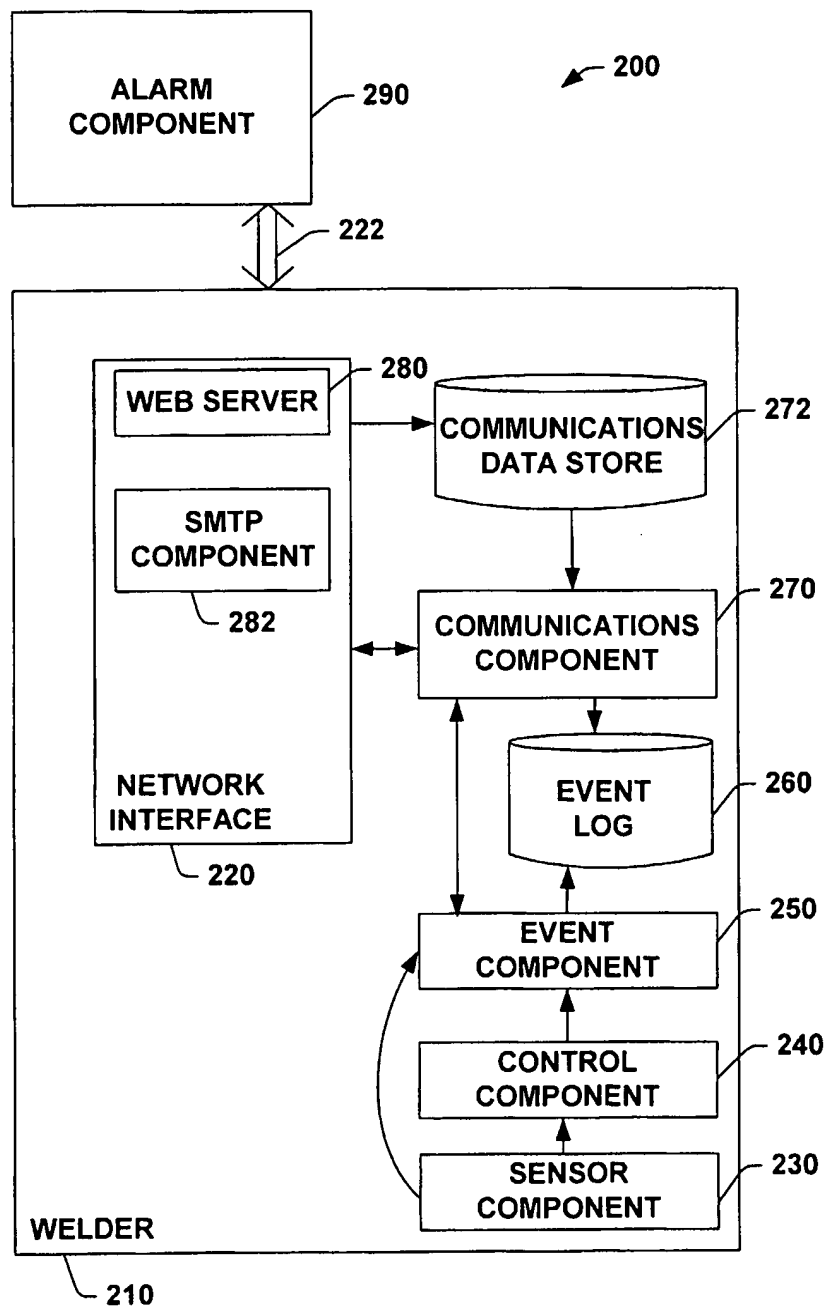


FIG. 1

2/9

**FIG. 2**

3/9

Type	Code	Description	Corrective Action
Fault	31	Primary over current.	Cycle power.
Fault	32	CAP bank A under voltage.	Self-clearing as condition ceases.
Fault	33	CAP bank B under voltage.	Self-clearing as condition ceases.
Fault	34	CAP bank A over voltage.	Self-clearing as condition ceases.
Fault	35	CAP bank B over voltage.	Self-clearing as condition ceases.
Fault	36	Thermostat.	Self-clearing as condition ceases.
Fault	37	Soft start Failed.	Cycle power.
Fault	39	Glitch on the primary over current fault interrupt; possibly caused by noise or a signal level right at the trip threshold. (misc. hardware fault #1)	Self-clearing as condition ceases.
Fault	42	Power down. This is fault is not presently used.	Causes system reset or power down.
Fault	43	CAP delta; CAP A and B are out of balance.	Self-clearing as condition ceases.
Fault	44	Main CPU problem. The DSP has detected a problem with the CPU.	Self-clearing as condition ceases.
Fault	47	Glitch on the CAP/heart beat interrupt; possibly caused by noise or a signal level right at the trip threshold. (misc. hardware fault #2)	Self-clearing as condition ceases.
Fault	48	The main contactor opened unexpectedly. (misc. hardware fault #3)	Self-clearing.
Alarm	41	Secondary current has exceeded the long-term current threshold.	Maximum current level is reduced to 100 amps until the

Fig. 3

410

Event Log Contents:

Entry #	Code	Time Stamp	Data	Data	Description
1	49	04/20/01 12:15PM	Arc Current 300A	Arc Voltage 18.6V	<u>Alarm:</u> Loss of phase, max output threshold reduced.
2	41	04/20/01 2:58PM	Arc Current 325A	Arc Voltage 19.2V	<u>Alarm:</u> Exceeded secondary current threshold
3	41	04/20/01 3:42PM	Arc Current 325A	Arc Voltage 19.2V	<u>Alarm:</u> Exceeded secondary current threshold

Log entries are numbered from most recent(#1) to the oldest.

Apparent Problem:
Nuisance tripping of secondary overcurrent alarm caused by loss of an input line.

Suggested Action:
Check input power (fuses, cable, etc.).

420

Event Log Contents:

Entry #	Code	Time Stamp	Data	Data	Description
1	81	04/20/01 2:15PM	Motor Current 8.2A	Actual WFS 300 IPM	<u>Fault:</u> Wire drive motor overload.

Log entries are numbered from most recent(#1) to the oldest.

Apparent Problem:
Excessive wire drive motor current.

Suggested Action:
Verify no load operation of wire drive, and check feeding system for excessive drag (braking mechanism, conduits, torch liner, etc.).

Fig. 4

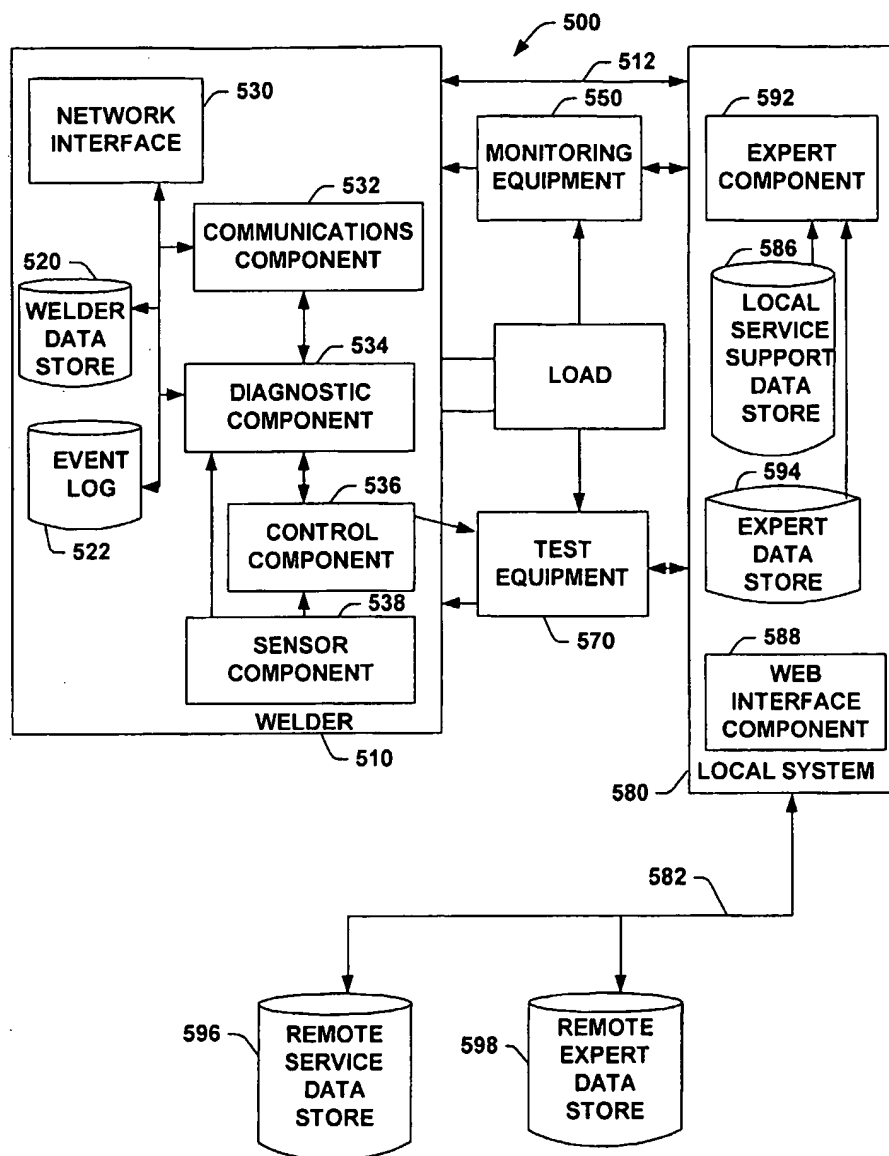


FIG. 5

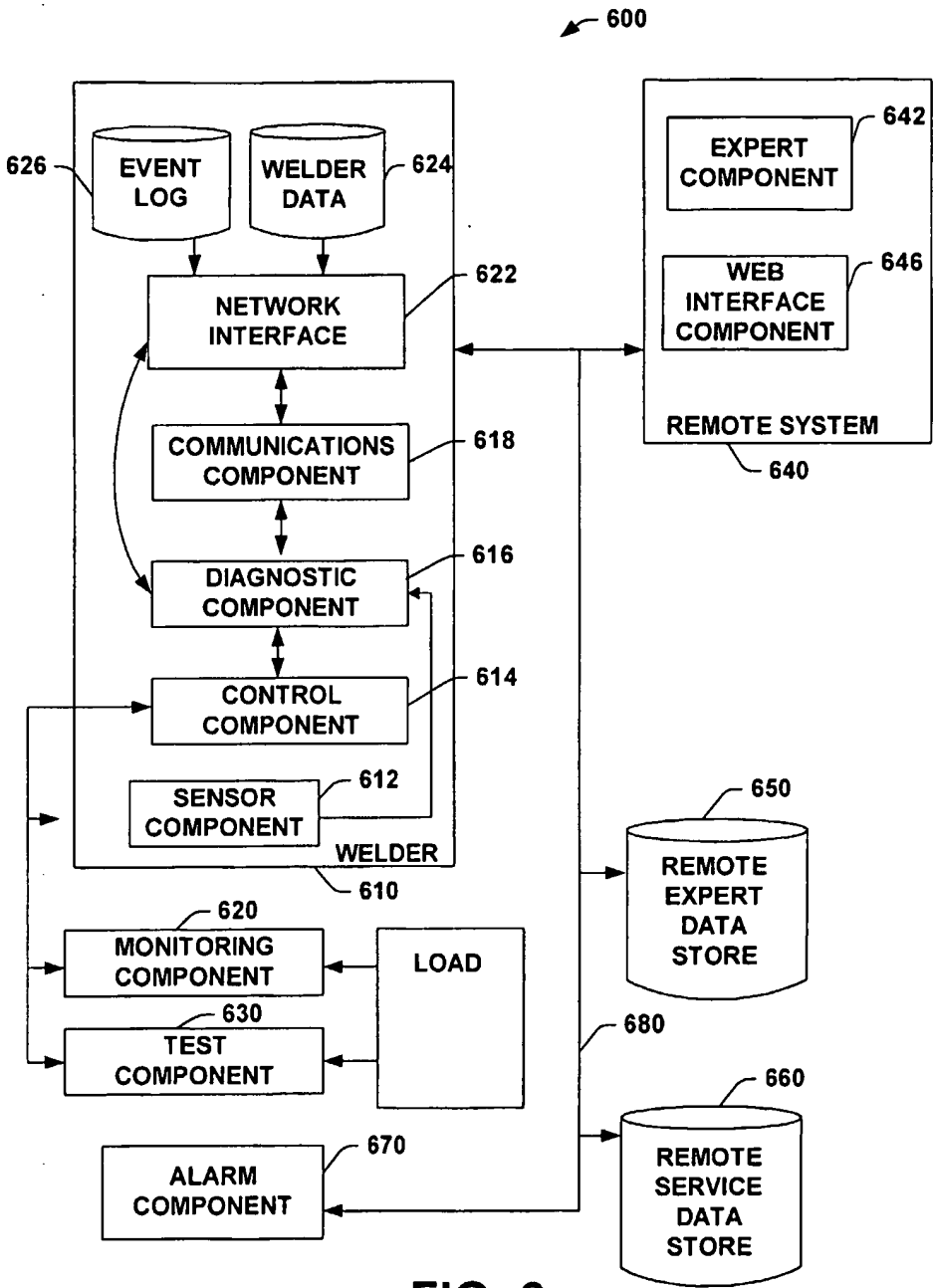


FIG. 6

7/9

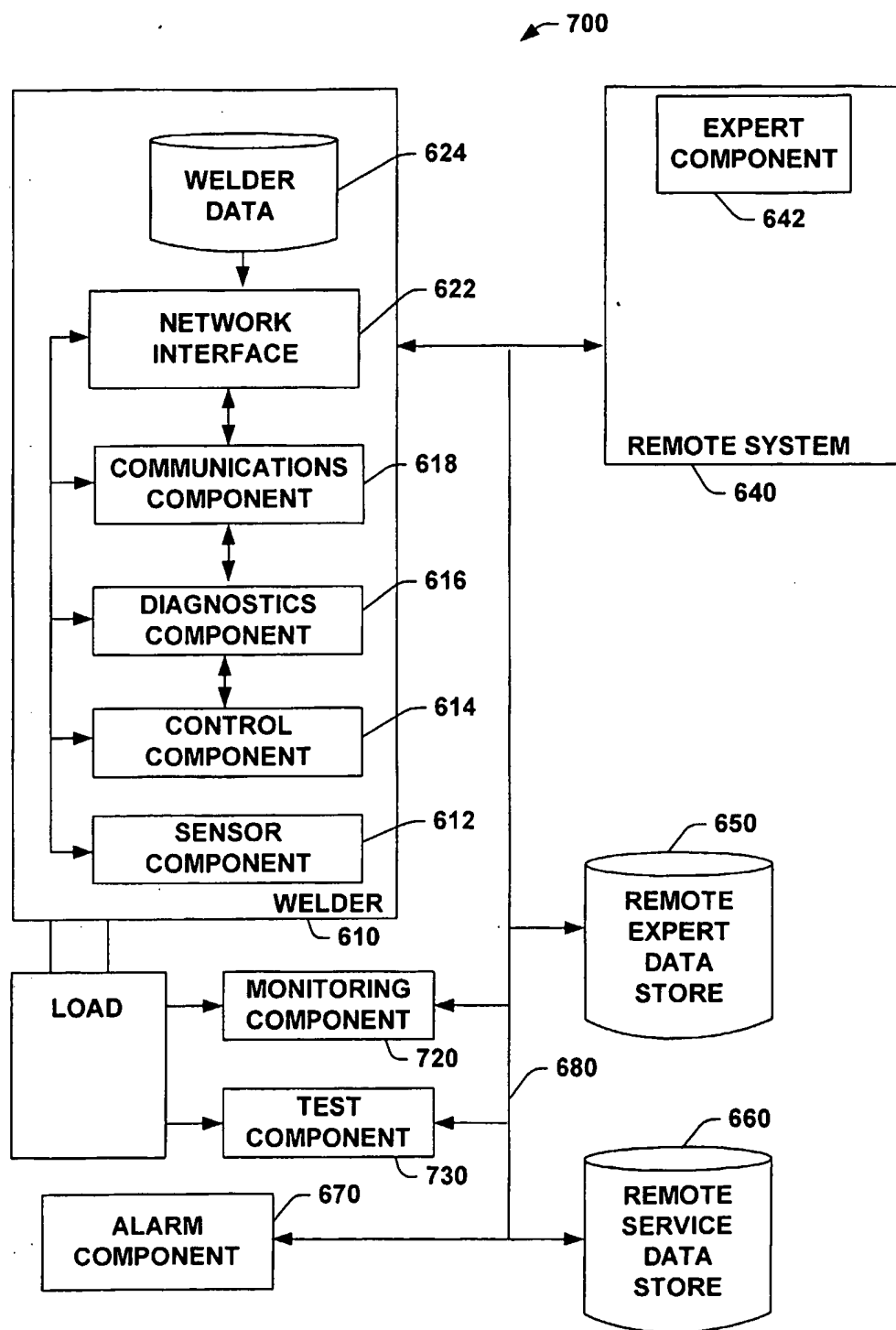


FIG. 7

8/9

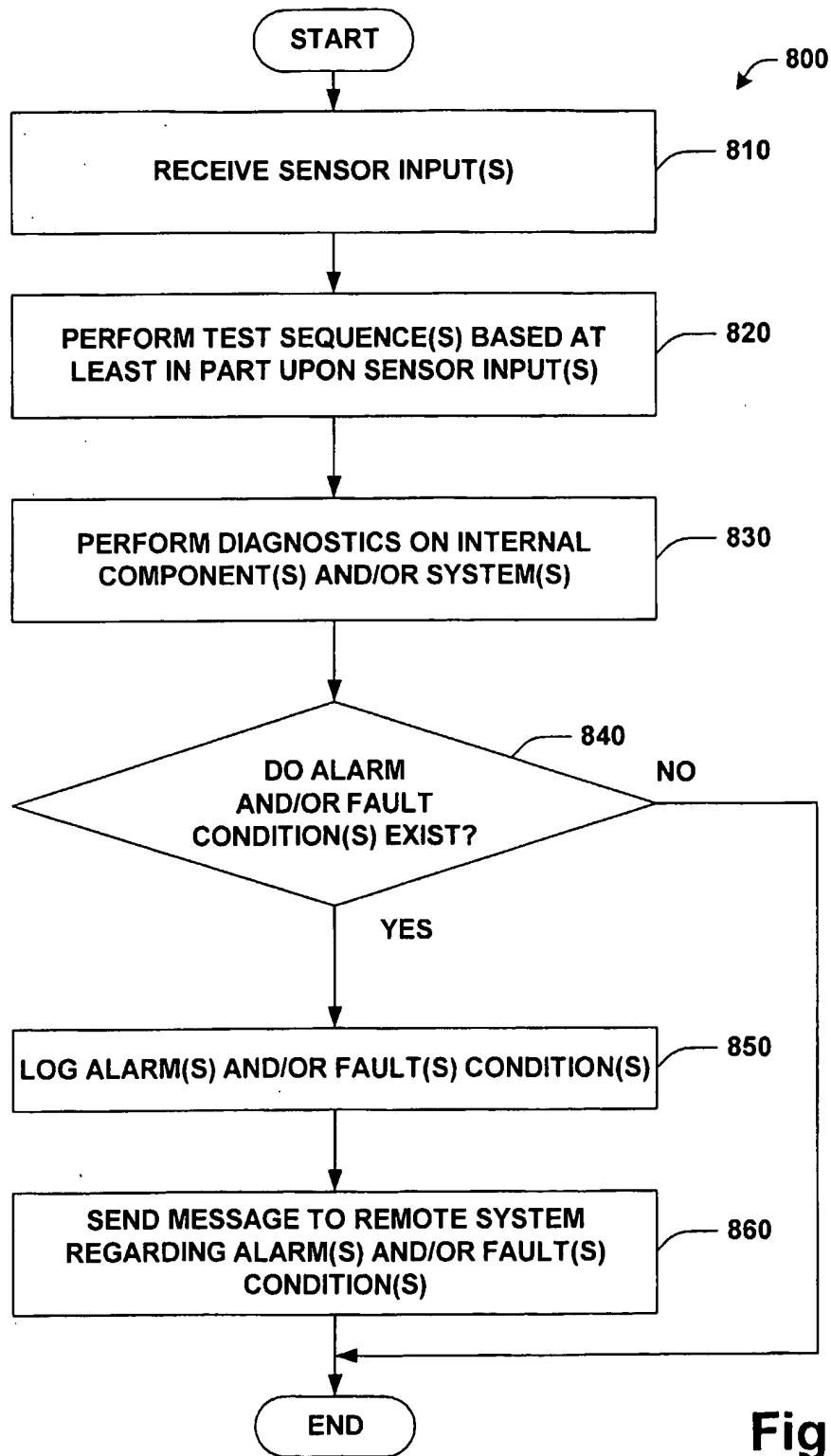
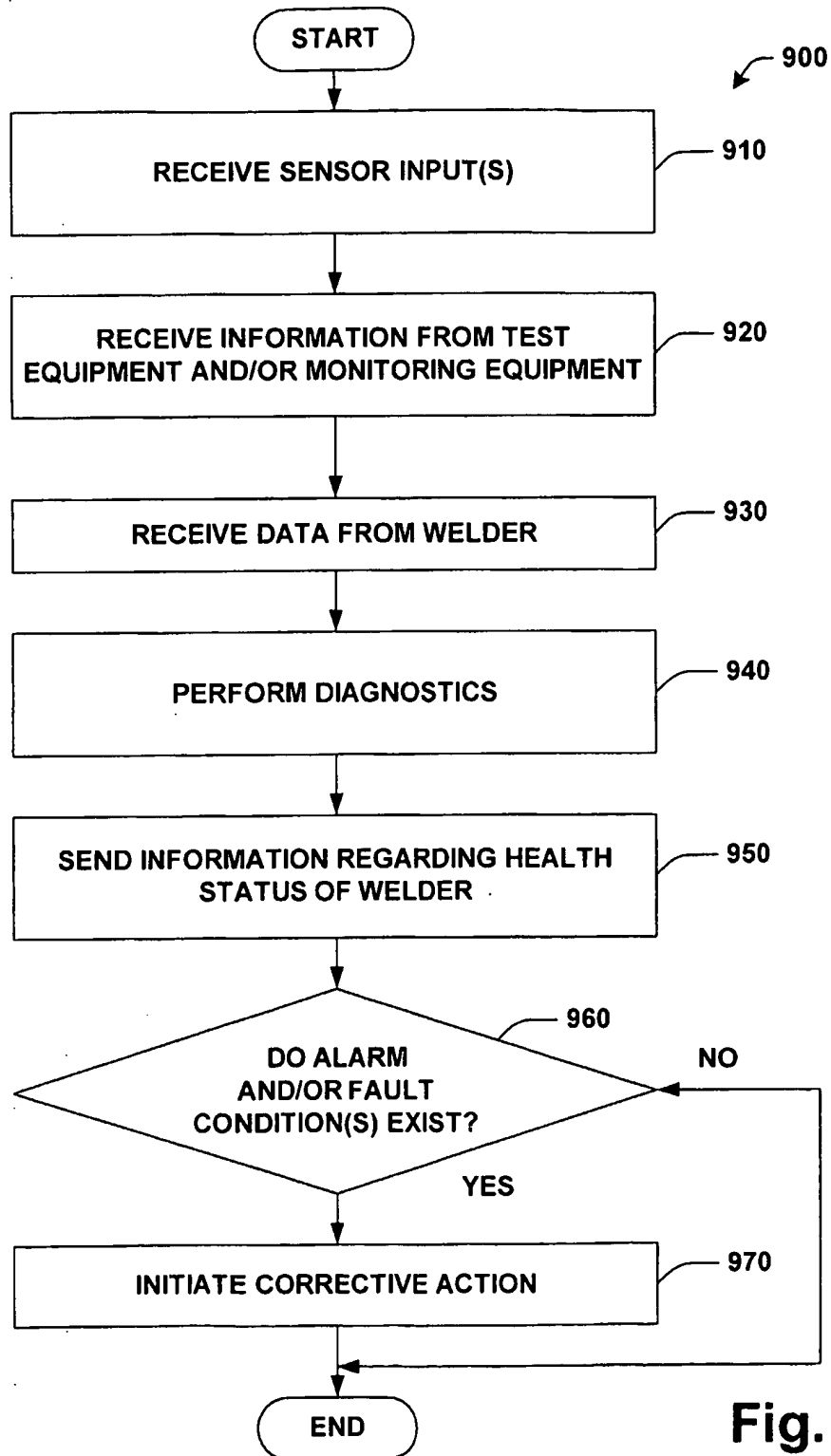


Fig. 8

9/9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/14388

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G01B 3/44, 52

US CL : 702/034

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 702/34,182; 340/540; 706/11

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,721,947 A (BROWN) 26 January 1988 (26.01.1988), Column 8 line 43; Col 13 lines 47-49, 72; and figure 2a.	1, 17, 27, 36, 38, 40

A		2-16, 18-26, 28-35, 37, 39
Y	US 6,041,287 A (DISTER et al.) 21 March 2000 (21.03.2000), figures 15, 17a, and 19.	1, 17, 27
Y	US 6,233,570 B1 (HORVITZ et al.) 15 May 2001 (15.05.2001), See abstract.	1, 17, 27

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

01 July 2002 (01.07.2002)

Date of mailing of the international search report

05 SEP 2002

Name and mailing address of the ISA/US

Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Facsimile No. (703)305-3230

Authorized officer

John S Hilten

Telephone No. 703-308-0956